



## REVIEW ARTICLE

## A review of traditional grain-based complementary foods for children aged 6-23 months in selected African countries

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## Abstract

**Background:** Wheat and maize flour still represent the bulk ingredient in complementary foods. There is an increasing interest in traditional cereal grain-based products due to their positive health effects. The positive health benefits include; more protein and fiber content than modern grains and most are naturally gluten-free. **Aims:** To identify available traditional grain-based complementary food options used for children aged 6-23 months in Africa, including the effects of various processing techniques on the nutritional value of the food products. **Material and Methods:** We searched SciELO, Google Scholar, AGORA, JSTOR, MedLine, ScienceDirect, SpringerLink, Wiley Online, and PubMed databases for the following (a) studies on the formulation of homemade or commercialized traditional grain-based complementary feeding porridges, (b) studies where traditional grains such as sorghum, finger millet, guinea millet, and pearl millet were used as the main ingredient. In addition, we evaluated the food processing techniques used, the resultant nutritional quality, and the acceptability of the product. **Results:** Thirteen eligible studies were identified. Traditional grains used frequently as complementary foods for children aged 6-23 months in Africa were pearl millet (*Pennisetum glaucum*), millet (*Panicum miliaceum*), sorghum (*Sorghum bicolor* L), and finger millet (*Eleusine coracana*). The most common techniques to improve the nutrition content of the foods were: fermentation, germination, and addition of legumes. Additionally, minor investigations have been carried out on effectiveness of these porridges in reducing malnutrition prevalence in this age group. **Conclusions:** In overall more studies are required with the focus on investigating the development of novel strategies to improve the nutritional profiles, safety, and acceptability of traditional grain-based complementary foods. Furthermore, their effectiveness to improve nutrition status of children needs to be investigated.

## Article information

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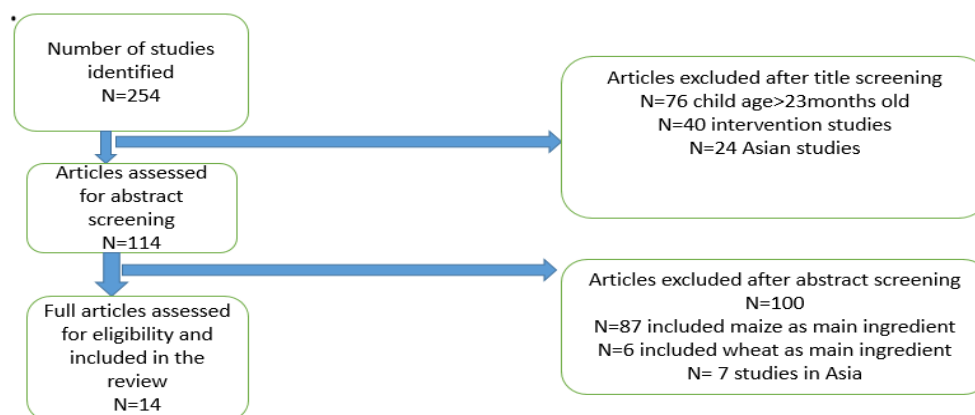
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## 1 Introduction

Complementary foods can be defined as any liquid or solid nutrient-containing foods given to young children in addition to breast milk <sup>1</sup>. Koletzko (2008) <sup>2</sup> further defined them as foods and liquids other than breast milk or infant formulas required during the second part of the first year of life for both nutritional and developmental reasons and also to enable transition from milk feeding to family foods. Adequate nutrition during infancy and early childhood is fundamental for optimum growth and development of children <sup>1</sup>. The “critical window” for the promotion of optimal growth, health, and behavioral development is the period from birth to two years of age <sup>1</sup>. World Health Organization recommends that infants should be exclusively breastfed for the first six months of life and thereafter should receive nutritionally adequate and safe complementary foods whilst breastfeeding continues up to two years of age or beyond <sup>2</sup>. After six months of age, breast milk is inadequate to

meet the macro- and micronutrient requirements of infants <sup>3</sup>. In developing countries, protein-energy malnutrition is highly prevalent due to many reasons that include failure to exclusively breastfeed as well as failure to give the right amounts of nutritious complementary foods to the children <sup>2</sup>. Traditional grains are crops mainly originating from Africa and are usually referred to as “Orphan crops” or “Lost crops” <sup>4</sup>. These traditional grains include sorghum (*Sorghum bicolor*), finger millet (*Eleusine coracana*), teff (*Eragrostis tef*), white fonio (*Digitaria exilis*), black fonio (*Digitaria iburua*), pearl millet (*Pennisetum glaucum*), guinea millet (*Urochloa deflexa*) and African rice (*Oryza glaberrima*) <sup>4</sup>. Traditional grains have numerous positive health benefits and these are mainly due to their constituents. They contain more protein and fiber than modern grains <sup>5</sup>, provide energy, promote satiety in drought-prone areas for communities reliant on them <sup>6</sup>, and are naturally gluten-free <sup>7</sup>. Further these cereals have shown anti-oxidant properties with or without processing <sup>8</sup>.



**Figure 1:** Search of publications related to traditional grain-based complementary foods for children aged 6-23 months in selected African countries

Diets rich in such grains are protective against non-communicable diseases such as cardiovascular diseases, some cancers as well as diabetes <sup>9</sup>.

Traditionally, cereal-based complementary foods constitute the main source of nutrients for children aged 6-23 months in Africa<sup>3</sup>. Traditional grains have great advantages as crops in the world are threatened by global warming; for example, sorghum is drought-tolerant and pearl millet can be cultivated under conditions of low rainfall <sup>4</sup>.

Over the past years, traditional grains such as finger millet and sorghum have mainly been grown for subsistence <sup>10</sup>. Limited attention by breeders and agronomists means yields remain worryingly low and yet they can withstand harsh conditions <sup>11</sup>.

A stable market requires trade and commercial products from the grains, however, this in turn requires a stable supply <sup>10</sup>.

The objective of this review paper is to summarize available evidence regarding the use of traditional grains in the production of complementary foods for children aged 6-23 months in Africa. In addition, a review of the effects of commonly used processing techniques on the nutritional profile of traditional grain-based complementary foods has been discussed.

## 2 Material and Methods

A search was conducted on SciELO, Google Scholar, AGORA, JSTOR, MedLine, ScienceDirect, SpringerLink, and PubMed. A population, concept, and context (PCC) framework was used to define search terms and guide screening of articles. In this study, the population group consisted of children aged between 6 and 23 months old. The concept was the phenomena of interest i.e., complementary feeding with traditional cereal grains. The context was geographical (Africa) and time-bound (studies in the last 20 years). The search syntax was therefore built using the following keywords and their synonyms: “complementary foods+children6-23months+traditional grains+Africa. Search techniques such as the use of Boolean operators (AND, OR, and NOT) to create a comprehensive search were applied.

The main criteria for inclusion of selected papers were: a) children aged between 6-23months; b) countries in Africa that utilize traditional grains; c) homemade and commercialized traditional complementary foods; and d) traditional grains: sorghum, finger millet, proso millet, and pearl millet. On the other hand, articles

**Table 1:** Traditional homemade complementary foods and main ingredients used in African countries for children aged 6-23 months

Main ingredients used	Product produced	Country	Ref
Pearl millet ( <i>Pennisetum glaucum</i> ), tigernut and crayfish	Flour blends	Nigeria	<sup>12</sup>
Millet ( <i>Panicum miliaceum</i> ), pumpkin seeds, carrots, cowpea leaves and skimmed milk powder	Nutrient-enhanced millet-based composite flour	Uganda	<sup>13</sup>
Millet ( <i>Panicum miliaceum</i> ), with sesame and soy	Porridge	Uganda	<sup>14</sup>
2 types of sorghum ( <i>Sorghum bicolor</i> . L) and the Variety 76T1#23	Porridge gruel	Ethiopia	<sup>15</sup>
Soybean- millet, soybean- sorghum, peanut-millet, peanut sorghum, cowpea-millet, cowpea-sorghum	Complementary food	Ghana	<sup>16</sup>
Sorghum, soybean, karkade and premix	Complementary food	Ethiopia	<sup>17</sup>
Finger millet and cowpeas	Complementary food	Kenya	<sup>18</sup>
Finger millet, kidney beans, peanuts, mangoes	Porridge	Tanzania	<sup>19</sup>
Sorghum and amaranth	Complementary food	Kenya	<sup>20</sup>
Sorghum, <i>Adansonia digitata</i> fruit pulp, <i>Moringa oleifera</i> leaf powder, and <i>Cochlospermum tinctorium</i> root powder	Complementary food	Benin	<sup>21</sup>
Pearl millet ( <i>Pennisetum glaucum</i> ), ginger, mint and black pepper	Fermented gruel ( <i>ben-saalga</i> )	Burkina Faso	<sup>22</sup>
Sorghum ( <i>Sorghum bicolor</i> ), groundnuts ( <i>Arachis hypogaea</i> ), mango ( <i>Mangifera indica</i> ) and spinach ( <i>Cnidioscolus chayamansa</i> )	Complementary food	Cameron	<sup>23</sup>
Sorghum ( <i>Sorghum bicolor</i> ), Irish potato and groundnut	Complementary food	Nigeria	<sup>24</sup>

were excluded when: a) research papers were older than 20 years; b) studies in which intervention was undertaken for supplementary and therapeutic purposes; and c) studies where maize and wheat were used as the main grains because they are not regarded as traditional grains. Articles written in English only were considered.

All database results were exported into Mendeley where duplicates were removed. The screening process was performed in three steps; first, titles of all articles were critically screened in order to ensure that they were linked to the study topic. Secondly, the abstracts of the selected papers were screened to remove irrelevant studies. Finally, the full texts of the articles were critically analyzed and reviewed to compile the relevant information needed. This information consists of the following; author, year, product, main ingredients, methods, other ingredients, resultant nutrient value, and country. This was recorded onto a data extraction template specifically created for the study. This process was checked and audited by two independent researchers.

### 3 Results

Our search identified 253 records (Figure 1: Search of publications related to traditional grain-based complementary foods for children aged 6-23 months in selected African countries). We excluded 140 studies for the following reasons; 76 studied children older than our cut-off of 23 months, 40 papers were intervention studies, and 24 papers were Asian studies. The final included papers were from Nigeria (n=2), Uganda (n=2), Ethiopia (n=2), Ghana (n=1), Kenya (n=2), Tanzania (n=1), Benin (n=1), Burkina Faso (n=1), and Cameron (n=1).

A summary of the traditional homemade complementary foods and the main ingredients used in African countries for children aged 6-23 months is presented in Table 1 (Traditional homemade complementary foods and main ingredients used in African countries for children aged 6-23 months). The results show that the main ingredients used in the production of complementary food products in the selected African countries were pearl millet (*Pennisetum glaucum*), millet (*Panicum miliaceum*), sorghum (*Sorghum bicolor*), and finger millet (*Eleusine coracana*).

### 4 Discussion

#### Main grain ingredients used in the production of traditional grain-based complementary foods

Traditional grains used frequently to make complementary foods for children between 6-23 months in Africa are millet, pearl millet, sorghum, and finger millet (Table 1).

**Table 2:** Methods used to process the traditional grains, other ingredients used and nutrient values of the complementary foods

Traditional grain	Other ingredients used	Methods	Resultant nutrient value	Ref
Pearl millet	Tigernut and crayfish	Germination	Protein 19.88% CHO 55.57% Zinc 6.0mg Iron 11.18mg	12
Pearl millet	Ginger, mint and black pepper	Fermentation	Energy 30kcal/100g	22
Sorghum	Amaranath	Germination	Protein 14.4% Fat 6.8% Ash 2.2%	20
Sorghum	Groundnuts ( <i>Arachis hypogaea</i> ), mango ( <i>Mangifera indica</i> ) and spinach ( <i>Cnidoscolus chayamansa</i> )	Fermentation	Protein 95.15% Carbohydrate 97.17%	23
Sorghum	<i>Adansonia digitata</i> fruit pulp, <i>Moringa oleifera</i> leaf powder, and <i>Cochlospermum tinctorium</i> root powder	Mixing	Iron 17.4mg/100g Zinc 1.2mg/100g	21
Sorghum ( <i>Sorghum bicolor</i> , L)	2 types of sorghum ( <i>Sorghum bicolor</i> , L) and the Variety 76T1#23	Germination	Protein 12.43% CHO 72.73% Iron 9.71mg Zinc 1.93mg	15
Millet	pumpkin seeds, carrots, cowpea leaves and skimmed milk powder	Germination Roasting	Protein 15.3% CHO 70.7% Iron 3.6mg Zinc 4.2mg Vitamin A 641IU	13
Millet	Soybean	Mixing	Energy 235 kcal Protein 9.7g Fat 4.4g	16
Sorghum	Soybean	Mixing	Energy 216 kcal Protein 9.8g Fat 4.0g	16
Millet	Peanut	Mixing	Energy 249 kcal Protein 8.4g Fat 7.9g	16
Sorghum	Peanut	Mixing	Energy 231 kcal Protein 8.5g Fat 7.5g	16
Millet	Cowpea	Mixing	Energy 222 kcal Protein 8.1g Fat 2.2g	16
Sorghum	Cowpea	Mixing	Energy 203 kcal Protein 8.2g Fat 1.7g	16
Sorghum	Soybean, karkade and premix	Mixing	Energy 425.51 kcal Iron 7.46mg Zinc 3.8mg	16
Finger millet	Cowpeas	Germination	Protein 7.29g	18

**Table 3:** The advantages and disadvantages of adding other ingredients to traditional grains during processing of complementary foods

Traditional grains	Legumes and other ingredients	Advantages	Disadvantages	Ref
Pearl millet	Tigernut and crayfish	- Tigernut has high levels of fiber, protein, carbohydrates, natural sugars (Soluble Glucose), the very high fiber improves the nutrient content, palatability, and content combined with a delicious taste make <sup>39</sup>	- High levels of fat in tigernut causes short shelf life	<sup>12</sup>
Sorghum	Irish potato and groundnut	- Irish potatoes are a rich source of protein, carbohydrates, minerals and vitamins <sup>40</sup> - Groundnuts are a rich source of oil and proteins <sup>41</sup>	- The complementary food produced had low mineral content due to the legume used with low mineral content	<sup>24</sup>
Millet	pumpkin seeds, carrots, cowpea leaves and skimmed milk powder	- Skimmed milk powder is rich in protein with balanced essential amino acids and high digestibility <sup>44</sup>	- Cowpea leaves have anti-nutritional factors <sup>45</sup> - Skim milk has low natural fat soluble vitamins <sup>54</sup>	<sup>13</sup>
Millet, sorghum	Soybean, peanut and cowpea	- Soybean is cholesterol free and is lactose free <sup>47</sup> - Cowpea is a low cost of proteins, iron and folates <sup>48</sup>	- Soybean can cause low shelf life because of the high fat content <sup>66</sup>	<sup>16</sup>
Sorghum	Soybean, karkade and premix	- Soybean is a good source of protein <sup>49</sup> - Karkade lowers cholesterol levels <sup>50</sup>	- Soybean reduces shelf life of the product <sup>51</sup>	<sup>17</sup>
Finger millet	Cowpeas	- Cowpeas is a good source of protein <sup>52, 53</sup>	- Cowpeas has antinutrients <sup>54, 55</sup>	<sup>18</sup>
Sorghum	Amaranath	- Amaranth contains plenty of fiber, protein and micronutrients <sup>56</sup>	- Amaranth contains antinutrients; oxalates and nitrates if not properly cooked <sup>56</sup>	<sup>20</sup>
Finger millet	Kidney beans, peanuts, mangoes	- Kidney beans are a good source of protein <sup>57</sup> - Mangoes are rich in minerals and anti-oxidants <sup>58</sup>	- Peanuts have a high quantity of saturated fats <sup>59</sup> - Dried mangoes have high sugar content <sup>60</sup>	<sup>19</sup>
Millet	Sesame and soy	- Soybeans are rich in protein and rich source of manganese, phosphorus and good source of iron and vitamin K <sup>61, 62</sup> - Sesame are good sources of calcium and B vitamins <sup>63</sup>	- Soybeans contain anti-thyroid compounds that disrupts the activity of the thyroid gland and results in goiter <sup>64</sup> - Sesame have higher oil content leading to reduced shelf life of the complementary food <sup>65, 66</sup>	<sup>14</sup>
Pearl millet	Ginger, mint, pepper and black pepper	- Ginger helps lower cholesterol levels <sup>67</sup> - Black pepper improves blood sugar control <sup>68, 69</sup>	- Excessive black pepper intake leads to burning sensations in the throat <sup>86</sup> - Mint causes heartburn <sup>71</sup>	<sup>22</sup>
Sorghum	Groundnuts ( <i>Arachis hypogaea</i> ), mango ( <i>Mangifera indica</i> ) and spinach ( <i>Cnidoscolus chayamansa</i> )	- Groundnuts are rich in protein and regulates blood glucose levels <sup>72</sup> - Mangoes contain immune boosting nutrients <sup>73, 74</sup> - Spinach promotes digestive regularity <sup>75</sup>	- Groundnuts may cause allergic reactions <sup>76, 77</sup>	<sup>23</sup>

The complementary foods, as shown in Table 1, which are primarily made from traditional grains, are frequently mixed with legumes such as groundnuts and beans to improve the content of the limiting nutrients in the cereal grains. The use of germinated sorghum flour in the formulation of complementary foods provides gruels of low viscosity and high energy and nutrient density, therefore, potentially increasing nutrient bioavailability <sup>15</sup>. Most of the complementary foods were from germinated millets and these were more acceptable and popular than those where sorghum was the main ingredient <sup>13</sup>.

## Common processing techniques of complementary foods in Africa and the effect on nutrient content

Different methods have been used to process the traditional grain-based complementary foods for children aged between 6-23 months in Africa. Fermentation, germination, steaming and

toasting have been applied either alone or in combination at single temperatures or varying temperatures <sup>25</sup>.

In studies that have used millet, the first step is always to clean and sort <sup>15</sup>, remove any foreign materials from the millet and

make the grain appropriate for eating without any dirt. Pearl millet was germinated for 72 hours and then fermented for 48 hours <sup>12</sup>. The results showed that an acceptable complementary food can be developed which to meet the nutritional requirements of children between 6-24 months <sup>2</sup>.

Food fermentation has been shown to effectively increase the nutritional composition of foods as well as decrease the levels of anti-nutritional factors (ANFs) and toxic constituents <sup>26, 27</sup>. Fermentation constitutes an important process that helps to lower the content of anti-nutrients (phytates, tannins, and polyphenols) of cereal grains. Fermentation can activate several endogenous enzymes which reduce anti-nutritional factors <sup>27</sup>. Fermentation activates starch hydrolyzing enzymes such as alpha-amylase and

maltase which degrade starch into maltodextrins and simple sugars<sup>28</sup>. The process of fermentation also increases the bioavailability of calcium, phosphorous, and iron likely due to the degradation of oxalates and phytates that are complex with minerals. thereby reducing their bioavailability<sup>28</sup>. Fermentation also improves organoleptic properties as well as extends the shelf life of food products<sup>29,30</sup>.

Germination has long been used to improve the functional properties<sup>31</sup> and nutritional value<sup>32</sup> of sorghum flour. In another study, Tizazu *et al.*<sup>15</sup> germinated sorghum grains at room temperature for 48 hours. This resulted in gruels of low viscosity, high energy, and nutrient density, therefore, potentially increasing nutrient intake in this age group. Kim *et al.*<sup>33</sup> outlined that germination increases various vitamins present in cereals and legumes such as tocopherols ( $\alpha$ -,  $\beta$ -, and  $\gamma$ -tocopherols), riboflavin (Vitamin B<sub>2</sub>), and total niacin (Vitamin B<sub>3</sub>) due to synthesis of these vitamins by the new sprouts. It has been hypothesized that the remarkable increase in phytase activity during germination helps reduce phytic acids, which bind minerals subsequently leading to increased mineral availability<sup>34</sup>.

Disruption of food matrices embedding various minerals helps to increase the bioavailability of minerals making fermentation and germination key in improving weaning and complementary foods for children, especially in regions where diet is predominantly plant-based<sup>35</sup>. In one study that used germination followed by roasting, millet was germinated for 1-2 days and then roasted<sup>13</sup> resulting in 15.3% protein content and iron content of 3.6mg/100g. Several studies have shown that germination improves the nutritive value of millet over the ungerminated seeds<sup>36</sup>. Germination in addition to soaking and roasting has been found to decrease the levels of antinutrients present in the grain and maximize the levels of some utilizable nutrients<sup>37</sup>.

In another study, finger millet was blended with precooked cowpea powder<sup>18</sup>. This resulted in increased protein content and protein digestibility in the flour from 6 to 39%. Technologies such as germination, fermentation, and cooking are simple and inexpensive and have been practiced for many years by communities in developing countries to process traditional grains. A summary of processing methods and nutrient content for complementary foods is shown in Table 2. The 13 studies analyzed the nutrient content of the resultant complementary food though not all nutrients were analyzed in all studies (Table 2). From nutrient analyses, it is shown that germination, fermentation, or a combination of the techniques give a higher protein content to the resultant porridge as compared to the use of non-germinated or fermented grain. In addition, when pearl millet was germinated at room temperature to make flour blends for complementary foods, protein content was 19.88%, carbohydrates 55.57%, zinc 6.0mg/100g, and iron 11.18mg/100g<sup>12</sup>.

When sorghum was steamed and toasted it resulted in the following levels of nutrients; protein level of 12.43%, carbohydrates 72.73%, iron 9.71mg/100g, and zinc 1.93mg/100g<sup>15</sup>. Steaming and toasting improved the texture of the final product and its nutritional value due to the temperature and time combination. However, the nutritional value was less than that of the germinated process.

When sorghum was germinated it resulted in protein content of 14.4%, ash 2.2%, and fat 6.8%<sup>20</sup>. In another study, pearl millet was treated with water and heat before grinding (conditioning) and the effect was that it met the protein needs of children between 6 months and 2 years by increasing the protein content from 7.27 to 7.85%. Germination of finger millet resulted in an iron level of 21.1mg/100g and protein digestibility of 76%<sup>19</sup>.

Roasting is a common processing step as it improves the taste of the final complementary food<sup>14</sup>. When millet was roasted it resulted in a protein level of 13.18%, carbohydrates 63.4%, iron 100.5mg/100g, and zinc 1.67mg/100g<sup>14</sup>. In contrast, when the millet was germinated and roasted, protein content was 15.3%, carbohydrates 70.7%, iron 3.6mg/100g, zinc 4.2mg/100g, and Vitamin A 641µg/100g<sup>13</sup>. There was an increase in protein and carbohydrate content. The much lower micronutrient levels could have been due to a shorter germination time or less than optimal germination conditions e.g., too low or too high temperature. Sorting and cleaning of millet grain had a higher protein content, compared to when it was germinated and roasted<sup>14</sup>.

In another study by Tatala *et al.*<sup>19</sup>, finger millet and kidney beans were initially soaked for 3 and 8 hours respectively and then left to germinate for 48 hours at 30°C and 80% relative humidity, washed, and then solar dried for three days. The solar-dried sprouts were then milled into fine flour and mixed in proportions with roasted ground peanuts, kidney beans, and solar-dried mashed mango puree. The mixtures were mixed in proportions of 75% finger millet, 10% peanuts, 10% kidney beans, and 5% mango (on a dry weight basis)<sup>19</sup>. Bioavailability of iron increased from 0.75 to 1.25mg/100g, viscosity was significantly raised by 12% and phytate concentration was reduced from 4.5 to 4.1mg/g<sup>19</sup>.

The review showed that adding other ingredients such as legumes improved the nutrient content of complementary foods. Addition of soybeans and peanuts was more advantageous for nutrient availability through the shelf life of the product was minimized. However, the technique of adding common allergens such as nuts may not be possible in populations with peanut allergy. Overall, complementary foods made from traditional grains appear to have higher acceptability when formulated with the addition of other ingredients compared to when formulated from a single cereal. This could be due to improved sensory qualities (taste, color, and flavor) and physicochemical properties such as rheology however,



more specific studies investigating factors affecting acceptability are required. The type of grain also appears to influence acceptability as most of the complementary foods from millets were more acceptable and popular than those where sorghum was the main ingredient<sup>13</sup>. This has some implications for novel food product development as food scientists must ensure that addition of other ingredients must be informed by existing and upcoming scientific evidence on their effects on nutritional qualities and physicochemical properties and find ways of increasing acceptability of less popular grains.

The types of legumes and other ingredients added to the traditional grains and their advantages and disadvantages have been outlined in Table 3.

Unlike in developing countries, the production of complementary foods in developed countries is more controlled, standardized, and regulated, due to improved technologies, high market demand, and government support<sup>78</sup>. Innovative products are also produced at a much faster pace due to continuous advances in food product development. In Europe, the recipes are based on five major staples that are locally available. These five are teff, maize, wheat, sorghum, and barley<sup>79</sup>. In Europe however, there is high inter-country variation in solid food offered during the complementary feeding period mainly due to the different local food traditions<sup>80</sup>. In England, baby rice is the most common (74%) first food offered to infants<sup>81</sup>, whereas in Sweden for example, potatoes, carrots, and sweet corn, or products made by these ingredients, are more commonly offered as the first foods<sup>82</sup>. The latter appears to be more micronutrient dense. In Italy, in a national survey conducted in 2000, fruit (73.1%) and cereals (63.9%), gluten-free 52.2%, with gluten 11.7% were the first solid foods used for most infants<sup>83</sup>. The common factor concerning complementary foods in Africa, Asia, and Europe is the influence of local traditions in selecting the different combinations. The differences mainly arise from the nutrient content with complementary feeds from developed countries being more micronutrient dense than those from developing countries.

In the Asia Pacific region foods are often given as the first choice, complementary foods comprise rice products (flour, barn, and cake), wheat flour, and roasted soy flour. In the Islamic Republic of Iran for example, the complementary foods include pudding (*fereny*) which consists of rice flour, sugar, and milk. The nutrient content is 107kcal/100g for energy density, protein 3-5g/100g, and fat 1g/100g. *Shir berenge* is another complementary food in the Islamic Republic of Iran which consists of rice and milk, the nutrient content is 67kcal/100g, protein 2-5g/100g, and fat 2-5g/100g. *Harireh badam* is a complementary food in the Islamic Republic of Iran that consists of almond, rice flour, and sugar, with nutritional value being 60 kcal/100 g, 3-5 g/100g, and 2-5 g/100 g of fat<sup>84</sup>. This indicates that in Iran the main ingredient of their complementary food is rice and the nutritional value

appears to be lower compared to the traditional grain-based complementary foods in Africa.

## 5 Conclusions

The study found out that the most commonly used traditional grains for production of complementary foods for children aged 6-23 months in Africa were millet (*Panicum miliaceum*), pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor. L*) and finger millet (*Eleusine coracana*). The most common processing techniques which had positive effects on the nutrients were fermentation and germination. Addition of legumes such as ground nuts and soybeans also improved the nutritional content of the complementary foods, especially the iron and zinc content. Conversely, very little investigation has been carried out on effectiveness of these porridges in reducing malnutrition prevalence in this age group. Overall, there is need for future studies to focus on investigating the development of novel strategies to improve the nutritional profiles, safety, and acceptability of traditional grain-based complementary porridges which might lead to commercialization.

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